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The American Midland Naturalist

PUBLISHED BI-MONTHLY BY THE UNIVERSITY
OF NOTRE DAME, NOTRE DAME, INDIANA.

VOL. IV.

JANUARY, 1916.

NO. 7.

HABITS OF WATERLILY SEEDLINGS.

BY J. A. NIEUWLAND.

[Plate XIV]

During several weeks study of an abundance of *Nuphar* and *Brasenia* material at Bankson Lake, Van Buren Co., Mich., in the late summer of 1914 and 1915 some interesting details of the habit of seedlings of these plants were obtained. The plants by their great number and peculiar response to the various environments to which they were subject, appeared particularly in congenial conditions for study of variations in development.

Noteworthy additions to our knowledge of *Nymphaea* seedlings as to habit and method of germination were brought out by Conard¹ in his Monograph on these plants. Seedlings of *Nymphaea tuberosa* Paine, [*Castalia tuberosa* (Paine) Greene] at Bankson Lake showed conditions of growth and response to surroundings as were outlined by Conard, and the members of the white waterlily group having been so thoroughly treated by that author only a few notes need here be added regarding leaf variation of the seedling of this plant. Sprouting tubers of the various members of the *Nymphaea* group such as *N. gigantea*, *N. mexicana*, *N. flavovirens*, *N. flava*, *N. elegans*, *N. zanzibarensis* var. *rosea* and a hybrid have their leaves shown on p. 75 bringing out a remarkable variety of these submersed members.

These plants have two very distinctly different kinds of leaves. The submersed aquatic, depending upon their age or succession of development and the depth in the water, show a tendency to enlarge and become broader. Smaller forms are found in shallow water where the penetration of light rays is

¹ Conard, H. S. The Waterlilies, a Monograph of the Genus *Nymphaea* Carn. Inst. Wash. (1905).

not cut out by silt and side refraction of the medium. These submerged leaves are, moreover, very thin, and when dried even filmy and easily broken and blown away by the slightest gust of air. Histologically the cells are more alike and more spherical or ovoid in shape. Their vascular tissue is reduced to a minimum since scarcely necessary, except the phloem part. The floating leaves are produced later and at any one time are fewer and smaller, quite thick, in fact miniatures in every way of those of the mature plant. Usually not more than two or three are found on one plantlet and oftener, but one in small specimens. Conard does not emphasize, as might be done, the variation of shape of the successive seedling leaves. As already referred to he selects aquatic leaves from the sprouting tubers rather than from seedlings, and whatever leaf variation in stages are taken up (p. 110) are at random picked from different species not serially shown as to age or successive appearance.

Examination of hundreds of seedlings of different ages of *Nymphala tuberosa* showed us that the different leaf forms of this one species vary as much if not more than of the tuberous growths. Such a series of aquatic leaf variations have been selected as typical from the so-called "coves" of Bankson Lake, and the originals kept in the University herbarium, and illustrated in figures 1-10 plate XIV. The dotted outlines indicate other forms from the type connected with them. The order of appearance in the growing seedling varies as the breadth of the leaf and the size of the basal lobe, the very earliest devoid of blade, the earlier narrow and quite devoid of lobes. The second leaf is usually narrowly lanceolate or linear (Fig. 1). A curious fact is the presence even on the same plantlet of sharp angular sinus at the insertion of the petiole (4, 5, 9, 10,) and rounded or even obtuse protrusion at place of insertion in these submerged seedling leaves. Fig. 5 represents that might well be taken for a specimen of the *Nuphar* group, but for the fact that other leaves on the same plant are unequivocally those of *Nymphaea*, and the adhering seed coat could not be mistaken. The seeds of *Nuphar* are large and shiny, those of *Nymphaea* small and black, those of *Brasenia* small and grayish white, both of the latter dull. The method of germination of *Nymphaea* seedlings were found to be the same as outlined by Conard.²

² ¹ c. p. 107:112.

BRASENIA SCHREBERI.

Seedlings of *Brasenia* in great numbers were studied and found to have the same mode of germination as those of *Nymphaea*. [Plate XIVa.] The following variations due to environment were observed. Seeds [S] embedded in mud often as much as four to six inches break open by protrusion of the cotyledon petioles carrying out the axil, from which the epicotyl arises as a long thread-like growth. The more or less delayed primary root passes downward [PR]. The epicotyl [EP] when reaching the surface of the mud or bottom of the pond, expands and produces a cluster of leaves of varying size but with the exception of the first few, of about the same shape. The cotyledons are permanently intraseminal and seem to serve no purpose except to suffer the transfer of food collected in them, to the seedling especially to the primary root and epicotyl until it has produced leaves. While so doing the cotyledons gradually wither away. All the submerged leaves are thin, and filmy when dried, and histologically nearly as in *Nymphaea*. The first blade-bearing leaf is narrowly oblong and the petiole is *not peltately inserted, but at the margin of one end*. The subsequent leaves are excentrically peltate the earlier ones just slightly intra-marginally inserted. The size of the leaves beneath the water depends on the depth of submersion, the plants in deep water bearing very large ones. After about 6-9 of these thin aquatic leaves have appeared, there arises a single smaller perfectly elliptical floating one [W] which is thick in texture and except for the absence of slimy exudation on the lower face characteristic of mature floating foliage and petiole, is quite a miniature of the older leaves. The stalk is very long, whereas the petioles of leaves of older plants are short, and the whole plant, stem and leaf cluster of maturer specimens arise to the surface of the water. The plants continue a succession of these long stalked floating leaves until a stem rises from the rooting plantlet, when the newly developed foliage begins to produce the slimy covering of the young immersed parts. *Brasenia* seeds not embedded in mud at the bottom, germinate without growing an elongated epicotyl, the seedling appearing to come almost directly from the axils of the cotyledons. It is not likely that seeds of this plant or *Nymphaea* would develop on or in mud above the water line. Such specimens could not be

found as was the case with *Nuphar*, giving rise thus to a new response to a new environment in the last named plant.

NUPHAR ADVENA.

Two distinct species of Yellow Pondlilies were found in Bankson and North Bankson Lakes. Both are abundant in sheltered muddy parts of the lakes called "coves." So readily were they distinguished at sight that my attention to the main differences was first called by a companion who had never studied botany. *Nuphar advena* grows nearer to shore as a rule but even in very deep location lifts its leaves entirely out of water. *Nuphar variegata* grows nearly always in deep places and the leaves always float. The petioles of the former are stout oval or almost orbicular in cross section and the basal sinus is open with wide spreading lobes. The lobes of the later are closed and the semicircular outline of petiole cross section shows two noticeable projections representing wings.

Fernald and St. John¹ consider Standley's estimate as to the size of the "floating leaves usually 17-28 cm. long and 11-22 cm. wide" "as unfortunate" or apparently extravagant. From herbarium specimens it is not always safe to conclude as to leaf-size, even if such a character means very much in some plants. There is a decided tendency not to collect the older and the largest leaves of plants, because they are in case of water plants especially, inconvenient to mount, or defective or broken by wind and eaten by insects. My herbarium specimens of these plants were very carefully made in the last few years, yet not with the idea of obtaining the largest sizes, though the largest young and perfect ones. Average sizes were obtained and their length is from 15-30 cm., and they are proportionately wide. I have seen numerous plants with older but torn leaves that were no less than 35 cm. long!

The rhizomes of both species of *Nuphar* can not be distinguished. The specimens of skins of those of *N. variegata* show perhaps closer arrangement of leaf insertions in phyllotaxy, and are found deeper in the mud, the roots usually arising only from the lower side in both. I have been unable to find aquatic foliage in blooming plants late in season, though in vegetative specimens of *N. variegata* such was occasionally met with. The flowers of

¹ Rhodora 16: 138 (1914).

the latter are notably larger and darker red and the stamens much more numerous. The crenate margined stigma has the lines in flower running to the edge, whereas in *N. advena* these do not reach the margin by one third or one fourth their length. The fruits of the last mentioned are deeply cratered and scarcely narrowed abruptly at the top. Whereas the fruits of the yellow pond lilies ripen above water or bend down eventually, the fertilized flowers of *Nymphaea tuberosa* are pulled down close to the bottom as the peduncle twists into a close spiral after the manner of *Valisneria* pistillate-flowered peduncles.

It was found impracticable to study seedlings of *N. variegata* because the plant always grew where *N. advena* was also found. There were, however, many places where the latter was exclusively to be found so that the seedlings obtained are with certainty those of the latter. Moreover, the plantlets of *N. variegata* which were indisputably such, were already too far advanced to show results, and too few to be worth while.

The seedling of *N. advena* exhibits more differentiation in response to environment than any of the other water lilies. Like those of *Brasenia* and *Nymphaea*, seeds of *Nuphar* buried in mud either at the bottom of the pond [b.e.] or above the water line [f] send out an elongated epicotyl with the primary root. On emerging from the darkness in the mud, aquatic leaves are produced which are thin and evanescent, their size varying as the depth of water or consequent absence of strong light. The first blade-bearing leaf is narrowly lanceolate to linear and the succeeding ones become broader and more orbicular and finally cordate obtuse at the apex or rounded, with reniform base, and with more or less rounded basal lobes. When found in deep water the submerged leaves are in texture and size like those of *Nymphaea tuberosa*, but of a yellowish green color. Leaves of plantlets of the same age in shallow clear water [d] are darker green and smaller. Seeds of the plant [c] not embedded in the mud of the bottom do not produce the characteristic elongated epicotyl. All *Nuphar* seedlings produce after the usual set of submerged leaves, one or two thick smaller floating leaves, as in *Brasenia* and *Nymphaea*. These are approximately miniatures as to shape and structure of mature leaves, but as they always float, they have no stomata on the lower face. An interesting characteristic of seedlings of *N. advena* not found in the others, *Nynphaeaceae*

not even in case of *Nuphar variegata*, is that the seeds germinate above the water line in or on mud. In this case no aquatic foliage whatever is produced [e.f.]. The leaves are the usual thick aerial ones with short stout petioles. They are even firmer and proportionately smaller than the floating ones. Even when not germinating below the water line, but when embedded in mud the seeds send out the elongated epicotyl [f.]. *N. advena* alone seems to have this last environment. The variation of shape in these aerial leaves is also a gradual one, the very earliest, however, are never as narrow as the younger aquatic ones. In fact should the water of a pond lower and leave plantlets with one or two aquatic thin leaves exposed to air, no more aquatic foliage is produced, but only aerial thicker leaves. Such changes from water exposure to air exposure of foliage and back again are rapid and frequent, due to the fact that the rise and fall of the so-called "floating islands" or musk-rat feeding-places occur. These animals undermine large patches of root-entangled bottom which rises and small islands float about. As the other plants on them die these patches often sink again. Around the muskrat "runs" these "floating islands" dip abruptly into deep water, and all the stages of *Nuphar* seedling environment may be found within the area of single square yard.

North Bankson Lake is muddier than the other lake as it has in very recent times been cut off by a sand-bar raised by wind and wave action. It is now much more sheltered and has rather large areas of these "floating islands" which have become a tangled mass of roots of *Carices*, *Cyperis*, *Scirpi*, *Junci*, *Eriophorum* and principally *Rhychospora macrostachya*, *Dulichium arundinaceum*, *Hermicarpha micrantha*, *Fuirena squarrosa*, one or two species of *Fimbristylis* and *Eleocharis*, many tall grasses *Xyris flexuosa*, *Peltandra virginica*, *Sparganium minimum*, *Eriocaulon septangulare*, and nearer the water line, *Utricularia intermedia* and *minor* growing with *Nuphar advena* seedlings. It is very unsafe to venture upon these patches without the aid of planks as they are real floating quagmires. Changes in environment to meet rapidly varying conditions are so frequent that the *Nuphar* seedlings accommodate themselves apparently to all the habitats in rapid succession. I have even found *Nuphar advena* seeds germinating in the almost dry drained bottom of a pond south of South Bend, where the older plants deprived of sufficient moisture were rapidly drying off.

PLATE XIV.

EXPLANATION OF FIGURES.

FIG. a. *Brasenia Schreberi* Gmel. Seedling illustrating habit of growth with thin aquatic submersed foliage and one quick floating leaf (W) when the seed germinates below the muddy bottom (BB¹). Ep Elongated epicotyl. (S), Seed, (PR), Primary root. (W) Thick aërial leaf. The other habitats are similar to the following of Figs. (b), (c), and (d).

FIG. b. *Nuphar advena* (Soland) R. Br. Seedling showing aquatic and floating leaves, and habit of the preceding. Parts labelled as in Fig. a.

FIG. c. Same with seed germinating at the bottom on the mud but not buried. No elongated epicotyl developed.

FIG. d. Same showing diminution in size of aquatic foliage when growing in shallow water with stronger light.

FIG. e. Same with aërial thick foliage when growing in mud above the water line (WW¹).

FIG. f. Same the seed germinating upon instead of below mud. Foliage as in the preceding (Fig. e); no aquatic leaves developed.

FIGS. 1-10. Variations in aquatic leaf shapes of seedlings of *Nymphaea tuberosa* Paine. The older leaves are broader with larger basal lobes.

All plants about $\frac{1}{2}$ to $\frac{1}{4}$ natural size. Drawing diagrammatic, the petioles of all naturally longer, particularly in case of floating foliage. Petioles of the air-exposed plants (Figs. e and f.) drawn in natural proportions. All plants drawn from herbarium specimens collected at Bankson and North Bankson Lakes in August, 1915.

ENUMERANTUR PLANTAE DAKOTAE SEPTENTRIONALIS VASCULARES.—IV.

ENUMERAVIT J. LUNELL.

The Vascular Plants of North Dakota.—IV.

With Notes by J. Lunell.

Sub-class 2. DICOTYLEDONEAE.

D. C. Syst. I., (1818), also Prodr. I., p. 1. (1814).

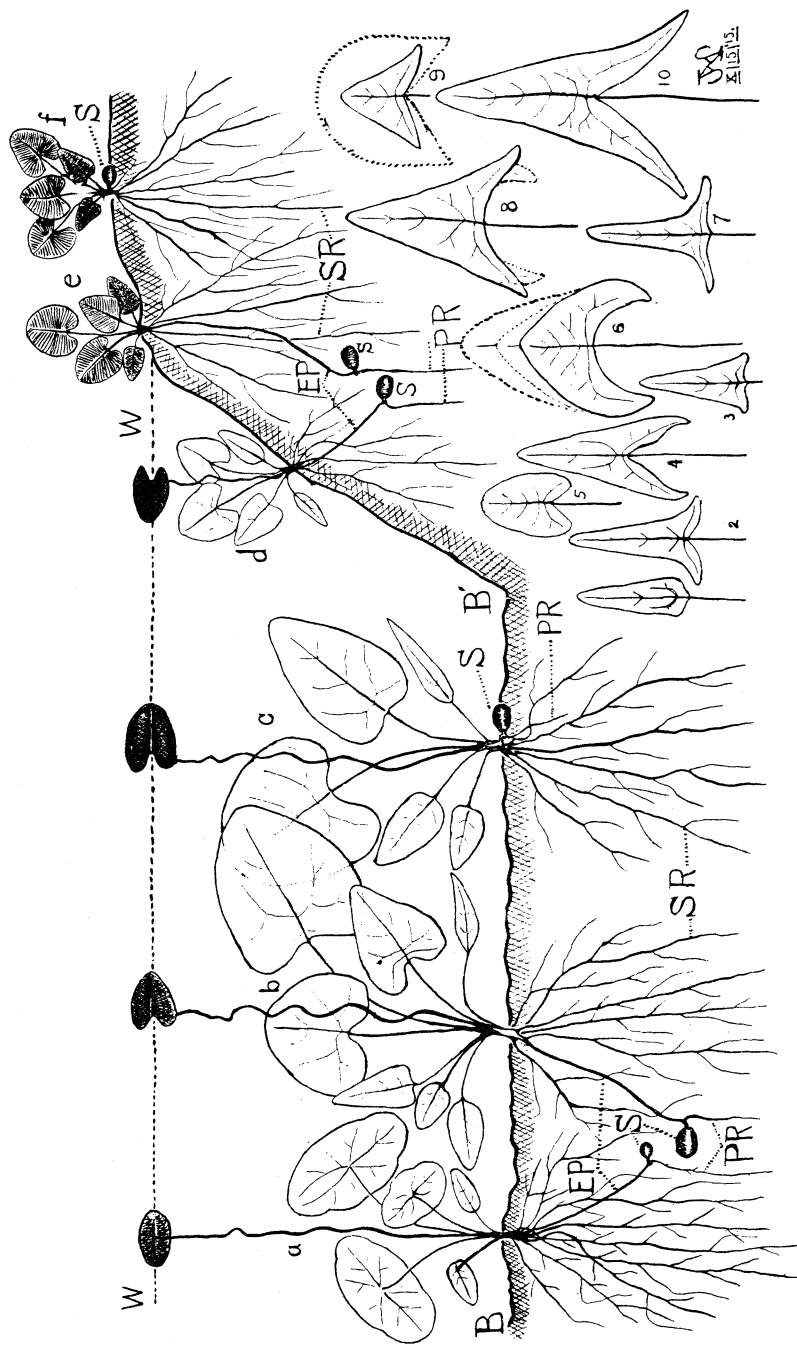
Order 16. SALICINAE.

Bartling, Ord. Nat. Pl. p. 118. (1830.)

Family 29. SALICINEAE L. Rich ex A. Rich. Nov. Fl. Bot. ed. 4, p. 560. (1828), also Lindley, Nat. Syst. ed. 2, p. 186. (1836).

POPULUS Virgilius Ecl. IX. 41, Plinius XXIV, 8, Horatius, Carm. 11. 3.

302. *Populus tremuloides* Michx. Fl. Bor. Am. 2. 243. (1803).



NIEUWLAND ON HABITS OF WATERLILY SEEDLINGS